Stable Isotopes of Nitrogen and Oxygen in Source Identification of Nitrate in Ground Water Near Umatilla, Oregon

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INTRODUCTION

Ground-water samples were collected in the vicinity of two food-processing waste-application sites in the Umatilla basin (fig. 1) and analyzed for the stable isotopes ^{18}N and ^{15}O of nitrate and major ions to determine if nitrate from food-processing waste could be differentiated from other sources of nitrate. Ground-water age dates also were determined to estimate the traveltime from the point of recharge to the sampling point. End-member mixing analysis (EMMA) was used to determine the fraction of water attributed to food-processing waste-application in each sample. The fraction attributed to waste-application was then compared to the isotope ratios of nitrate to determine if nitrate from food-processing waste-application has a diagnostic isotope signature.

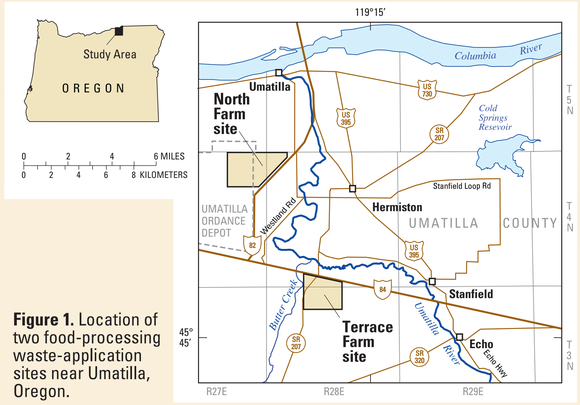


Figure 1. Location of two food-processing waste-application sites near Umatilla, Oregon.

NORTH FARM SITE

- Food-processing waste-water application site since 1972. A landfill is located downgradient from the western land application fields (fig. 2).
- Ground-water flows radially away from the land application site.
- Apparent ground-water age dates indicate that high concentrations of nitrate are present even in wells that have age dates >50 years and thus have not been impacted by the waste-water application (fig. 3).
- Solute-solute plots indicate three probable end-members (upgradient of the landfill, downgradient of the landfill, and shallow ground water beneath the North Farm land application site, figs. 4*A*-*B*).
- EMMA indicates that most samples had a mixture of water from upgradient and downgradient of the landfill, and only three samples (11-3, MW-4, and MW-10,) had a significant fraction of shallow North Farm water (table 1).
- EMMA also indicates that nitrate does not behave conservatively at this site (fig. 5) as measured nitrate concentrations and concentrations predicted with EMMA using major ion data do not plot along the 1:1 line.
- A regression of the nitrate isotope ratios against the fraction of shallow North Farm water did not show a significant relation for ^{15}N or ^{18}O at α=0.05.

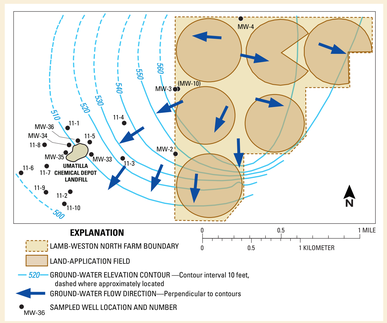


Figure 2. Well locations, ground-water flow, and other features at the North Farm site.

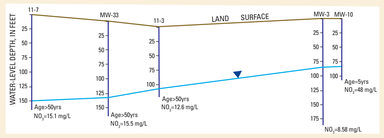


Figure 3. Apparent ground-water age dates and nitrate concentrations along a North Farm site cross-section.

Table 1. Proportions of water attributed to each end-member at the North Farm site.

Well No.	North Farm water	Downgradient of landfill	Upgradient of landfill
11-1	0	0.55	0.45
11-2	0	1.00	0
11-3	0.2	0	0.8
11-4	0	0	1.00
11-5	0.02	0.07	0.91
11-6	0.02	0.63	0.35
11-7	0	0.57	0.43
11-8	0	0.46	0.54
11-9	0	0.64	0.36
11-10	0	0.43	0.57
MW-3	0	0	1.00
MW-4	0.18	0	0.82
MW-10	1.00	0	0
MW-33	0.05	0.01	0.94
MW-34	0	0.74	0.26
MW-35	0	0.77	0.23
MW-36	0	0.38	0.62

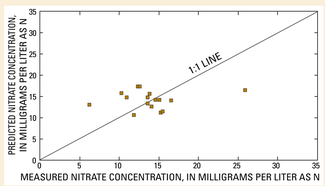
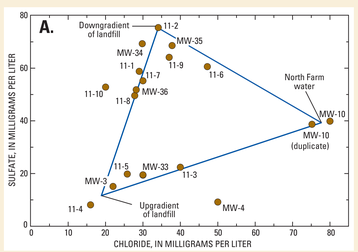


Figure 5. Measured nitrate concentrations and concentrations predicted with EMMA using major-ion concentration data.



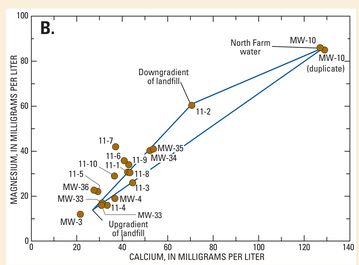


Figure 4. Sulfate-chloride **(A)** and magnesium-calcium **(B)** relations for North Farm samples. Probable end-members are at the three points of the triangles.

TERRACE FARM SITE

- Food-processing waste-water application site since 1981. Prior to being a waste-water application site, the principal land uses were irrigated agriculture and unfarmed dryland. A cattle feedlot operates just downgradient of the waste-water application area (fig. 7).
- Ground water flows to the northwest beneath the land-application site.
- Solute-solute plots indicate three probable end-members (upgradient groundwater, groundwater impacted by irrigation canal leakage and terrace farm water, figs. 8*A*-*B*).
- EMMA indicates that most samples had a mixture of water from the upgradient groundwater and groundwater impacted by canal leakage, and only two wells(MW-51, and MW-53) had a significant fraction of Terrace Farm water (table 2).
- EMMA also indicates that nitrate does not behave conservatively at this site (fig. 9) as measured nitrate concentrations and concentrations predicted with EMMA using major-ion data do not plot along the 1:1 line.
- A regression of the nitrate isotope ratios against the fraction of Terrace Farm water did not show a significant relation for ^{15}N or for ^{18}O at α=0.05.

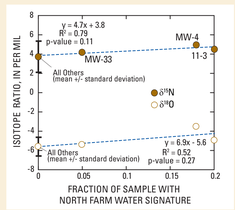


Figure 6. Relation between nitrate $\delta^{15}N$ and $\delta^{18}O$ isotope ratios and fraction of North Farm water.

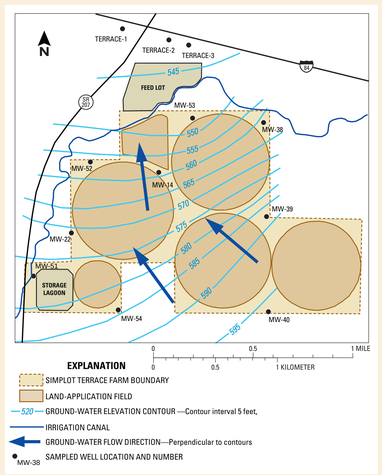


Figure 7. Well locations, ground-water flow, and other features at the Terrace Farm site.

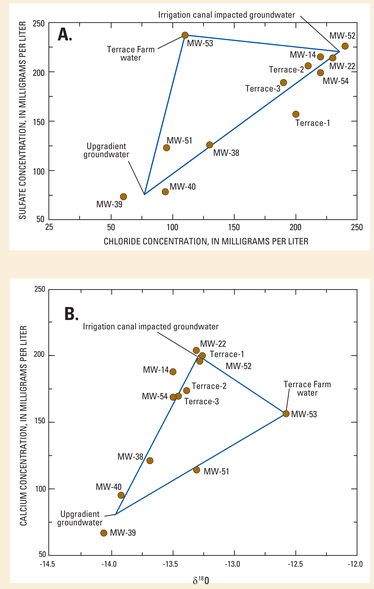


Figure 8. Sulfate-chloride **(A)**, Calcium-$\delta^{18}O$ **(B)** relations for Terrace Farm samples. Probable end-members are at the three points of the triangles.

Table 2. Proportions of water attributed to each end-member at the Terrace Farm site.

Well No.	Upgradient groundwater	Irrigation canal leakage	Terrace farm water
MW-14	0.11	0.89	0.00
MW-22	0.01	0.99	0.00
MW-38	0.64	0.31	0.05
MW-39	1.00	0.00	0.00
MW-40	0.92	0.08	0.00
MW-51	0.58	0.00	0.42
MW-52	0.00	1.00	0.00
MW-53	0.00	0.00	1.00
MW-54	0.19	0.81	0.03
Terrace-1	--	--	--
Terrace-2	0.15	0.82	0.03
Terrace-3	0.24	0.72	0.04

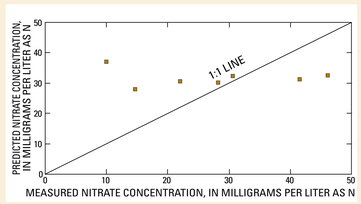


Figure 9. Measured nitrate concentrations and concentrations predicted with EMMA using major-ion concentration data.

CONCLUSIONS

- Nitrate is not conservative at these sites; other sources are contributing and some denitrification is occuring.
- Nitrate is elevated in pre-1950s water at the North Farm site, which indicates a substantial source of nitrate that pre-dates waste-water application.
- Overall, ^{15}N and ^{18}O do not help distinguish the sources of nitrate in ground water at these sites (fig. 10).
  - Relation between ^{18}O in nitrate and fraction of process water is not significant.
  - Relation between ^{15}N in nitrate and fraction of process water is not significant.

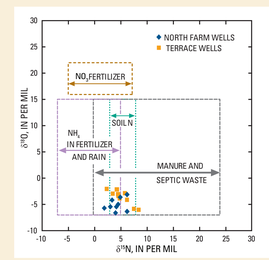


Figure 10. $\delta^{18}O$ and $\delta^{15}N$ ratios for nitrate in study site samples compared to the range of ratios expected for different sources of nitrate.

For additional information:

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